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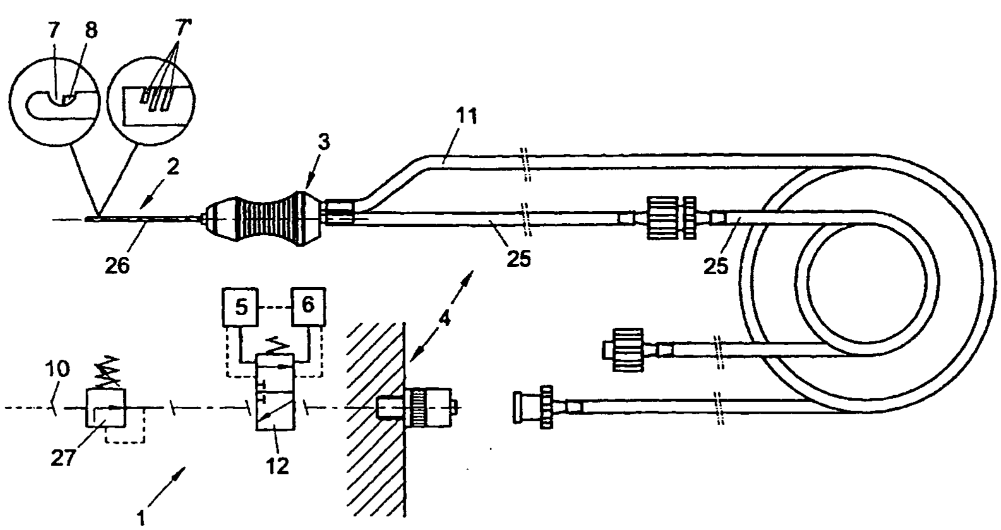
(54) Title: SURGICAL PNEUMATIC CUTTER



(57) **Abstract:** A surgical pneumatic cutting device, in particular for cutting eye tissue, comprises a cutting tool and a pneumatic drive for inducing a cutting movement at a variable cutting frequency. The device further comprises a compressed air supply and a compressed air pulse frequency control. According to the invention control means are provided to reduce the compressed air pulse energy with increasing pulse frequency. The control means may comprise pulse width modulation means.

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Title: SURGICAL PNEUMATIC CUTTER

The invention relates to a surgical cutter according to the preamble of claim 1.

Such a surgical cutter is known from US 5,630,827 and is applied for cutting eye tissue.

US 5,630,827 describes a pneumatic cutter with a compressed air supply which is provided with a frequency control for controlling the pulse frequency in which the compressed air pulses are supplied to the drive. From the passage in column 4, lines 42 - 49, it appears that only a clock circuit 721 is present. It is not described that the amount of energy supplied per compressed air pulse can be reduced with increasing pulse frequency.

US 4,940,468 also describes a pneumatic cutter provided with a compressed air supply whose pulse frequency can be controlled. Fig. 12 merely shows that the pulse frequency can be controlled, not that the amount of energy supplied per compressed air pulse can be controlled.

US 4,838,259 describes a respiratory support device provided with control means for modulating, depending on a pulse frequency, the width of an air pulse to be delivered by a compressed air valve. US 4,838,259 does not describe that such a device can be applied to reduce the energy supplied per compressed air pulse at a higher pulse frequency in order to compensate for an amount of compressed air energy still present in a compressed air cylinder of a pneumatic drive of surgical cutting tools.

The known cutting instrument is often referred to by the skilled person by the name of vitrectome. Usually, the cutting member comprises a knife arranged to be movable along a cutting opening. By means of a drive designed as a pneumatic operating cylinder, the knife is driven along the cutting opening in a reciprocating manner. To this end, the pneumatic drive is furnished with compressed air pulses by means of a compressed air supply. The compressed air supply comprises a compressed air hose, connectable to a compressed air source, which, via an electromagnetically controllable

compressed air valve, is furnished with compressed air pulses which are supplied to the drive. The compressed air pulses then effect an outward stroke of the plunger of the operating cylinder, whereby the knife is driven to close off the cutting opening. A return stroke of the compressed air cylinder, and consequently the opening of the cutting opening, is realized by means of a spring acting on the plunger. During the return stroke, the compressed air pressure in the chamber of the operating cylinder is released through a valve to the outside air or the compressed air hose.

During use of the cutter, the pulse frequency in which the compressed air pulses are supplied to the drive can be set with the help of a frequency control. Thus, the cutting frequency can be controlled depending on the desired cutting speed. Particularly when cutting delicate tissue, such as eye tissue, it is important that a sufficiently high cutting frequency can be realized. Furthermore, it is important that the cutting frequency be adjustable, and preferably continuously variable, from a low cutting frequency up to the high cutting frequency.

A drawback of the known pneumatic cutter is that the maximum cutting frequency is not sufficiently high. In particular, the maximum cutting frequency of the known pneumatic cutter is limited to about 800 cutting movements per minute. Above this cutting frequency, the plunger in the known device is found not to return to the initial position, and the cutting opening remains closed.

It has already been proposed to provide a cutter with an electric drive to realize a higher maximum cutting frequency. However, this has the drawback that such an electrically driven cutter is of relatively heavy and large design, which is experienced by surgeons as a serious limitation. Furthermore, a cutter having an electric drive is relatively complex and, moreover, difficult to sterilize, which, in a surgical environment, is very disadvantageous.

The object of the invention is to provide a cutter of the type mentioned in the preamble, with which, while maintaining its advantages, the drawbacks mentioned are avoided. To that end, the cutter according to the invention is characterized by the features of claim 1.

What is thus achieved is that in an elegant manner a considerably higher maximum cutting frequency can be realized. In particular, with the help of the known device, without mechanical adaptations, the maximum cutting frequency can be considerably increased, for instance to at least 1,200 cutting movements per minute.

The invention is based on the insight that, with the known cutter, during the return stroke of the plunger an air pressure is built up in the chamber of the operating cylinder and that, at higher pulse frequencies, this pressure has not yet been enabled to be discharged from the chamber. As a consequence, at frequencies above 800 cutting movements, i.e. complete reciprocating movements, per minute, the known cutter can no longer return to the opened position. By presently reducing the energy supplied per compressed air pulse at higher pulse frequencies, it is achieved that compensation is possible for the compressed air energy still present in the cylinder, so that, during the return stroke, the piston can indeed return to the initial position through spring action. Although outlined here on the basis of a specific type of pneumatic drive of the cutter, the invention, as will be clear to the skilled person, is advantageously applicable to other types of pneumatic drives for surgical cutting instruments.

Advantageously, the amount of compressed air energy supplied with each pulse is controlled by modulation means which modulate the width of the compressed air pulse, i.e. the pulse time, depending on the pulse frequency. In this manner, with increasing pulse frequency, the width of the compressed air pulse is shortened. Naturally, it is also possible to modulate the pressure of the compressed air pulse.

Preferably, the control means comprise a microprocessor. Thus, it is achieved that in an elegant manner, without substantial mechanical adaptations to the known cutter, a linear control of the cutting frequency can be realized.

A further advantageous embodiment further comprises means for measuring the compressed air pressure in the cylinder and/or supply line, in particular during the return stroke of the compressed air cylinder. Thus, it is achieved that on the basis of measurements, the amount of compressed air energy supplied with the compressed air pulse can be adjusted to the energy still present in the compressed air cylinder, so that an optimal drive can be realized.

In yet another embodiment, the compressed air supply for supplying the compressed air in pulses comprises at least two compressed air supply valves, preferably arranged parallel, which are operated in opposite phase. What is achieved in this manner is that the pulse frequency can be increased in an elegant manner; in the known cutter, even a cutting frequency of 2,000 cutting movements per minute can be achieved.

The invention also relates to control means for reducing the energy of compressed air pulses with increasing pulse frequency.

Further advantages of the invention are reflected in the subclaims.

The invention will be further elucidated on the basis of an exemplary embodiment which is represented in a drawing. In the drawing:

Fig. 1 shows a schematic representation of the different parts of the surgical eye cutter;

Fig. 2 shows a schematic cross section of the pneumatic drive and the cutting member; and

Fig. 3 shows an electronic diagram of a control for modulating the length of the compressed air pulses depending on the frequency.

It is noted that the figures are only schematic representations of an exemplary embodiment. In the figures, identical or corresponding parts are designated by the same reference numerals.

Fig. 1 shows the different parts of the surgical eye cutter 1. The eye cutter 1 comprises a cutting member 2 and a pneumatic drive 3 accommodated in a handle. The cutter 1 further comprises a compressed air supply 4 for supplying compressed air in pulses to the drive 3, so that it can drive the cutting movement of the cutting member 2 at a cutting frequency. The cutter 1 further comprises a frequency control 5 for controlling the frequency with which the compressed air pulses are supplied to the drive 3. Additionally, the cutter 1 comprises control means 6 for reducing, with increasing pulse frequency, the energy supplied to the drive with each compressed air pulse. In this exemplary embodiment, the control means are designed as a microprocessor 6.

Fig. 1 shows that the cutting member of the cutter 1 comprises a knife 8, arranged to be movable along a cutting opening 7. By means of the drive 3, the knife is driven to reciprocate along the cutting opening 7. The drive 3 is designed as a pneumatic operating cylinder 9 and will be further described hereinafter with reference to Fig. 2. The compressed air supply 4 comprises a compressed air hose 11, connectable to a compressed air source 10, and which is furnished with compressed air pulses through an electromagnetically controllable compressed air valve 12, which pulses are fed to the drive 3. The compressed air pulses then effect an outward stroke of the plunger 13 of the pneumatic operating cylinder 9 (Fig. 2). The knife 8 is thereby driven to close off the cutting opening 7. A return stroke of the operating cylinder 9, whereby the cutting opening 7 is opened, is accomplished by means of a spring 15 which acts on the plunger 13. In the return stroke, the compressed air pressure in the chamber 15 of the operating cylinder 9 is discharged through a valve to the outside air or to the compressed air hose 11.

Again referring to Fig. 1, it is shown that the cutter further comprises a frequency control 5 for controlling the pulse frequency in which the compressed air pulses are fed to the drive 3. The frequency control 5 is designed as an electronic circuit which is coupled to the electromagnetically operable compressed air valve 12. With the help of the frequency control, the number of compressed air pulses delivered by the compressed air valve per unit time can be set, for instance from 1 to 1,500 pulses per minute. Such frequency controls are known to the skilled person and will therefore not be further elucidated here.

During use of the cutter 1, by means of the frequency control 5, the pulse frequency in which the compressed air pulses are fed to the chamber 15 of the operating cylinder 9 can be set, so that the cutting frequency of the cutting member can be adjusted to the cutting speed with which the cutting member 2 is moved through the tissue to be cut. Through the control means 6 designed as modulation means, with increasing frequency of the pulses, the width of the individual pulses can be reduced. An example of the modulation of the pulse width, depending on the pulse frequency, is, for instance, a linear decrease of the pulse width from 30 milliseconds to 8 milliseconds at a linearly increasing frequency from 1 to 1,350 cutting movements per minute. Preferably, the height of the pressure of the compressed air pulses then remains the same. In this way, the pneumatic energy supplied to the chamber 15 per compressed air pulse can be compensated in a simple manner for the energy which, to an increasing extent with increasing cutting frequency, is left behind in the chamber, i.e. has not dissipated yet, during the return stroke of the plunger 13. Preferably, the modulation means comprise an electronic control. The constructional details of such a pulse width modulation control will be clear to the skilled person.

In Fig. 3 it is shown how the frequency control 5 and the pulse width modulation means 6 can be integrated in a microprocessor 16. The microprocessor 16 is coupled, via an analogue/digital converter 17, to a foot

pedal 18 with which the desired cutting frequency can be set. Further, the microprocessor 16 can be coupled to a computer via a standard RS 232 input port 19, to program the desired relation between the increase of the frequency and the decrease of the pulse width. At an output side, the microprocessor 6 is connected via a buffer 20 to the electromagnetically operable compressed air valve 12.

The microprocessor 16 can further be coupled to pressure measuring means by which the air pressure present in the chamber 15 during the return stroke can be measured, so that, depending on the desired cutting frequency, the amount of compressed air energy supplied per compressed air pulse to the chamber 15 can be adjusted to the air pressure still present, in such a way that the return stroke of the plunger 13, under the action of the spring 14, can still be just realized and the knife 8 will still leave the cutting opening 7 just clear entirely.

Once again referring to Fig. 1, there is shown that the cutting member 2 can also be provided with several cutting openings 7'. In addition, Fig. 1 shows that the cutter 1 is further equipped with a suction line 25. By means of the suction line 25, via a hollow, needle-shaped part of the cutting member 2, the tissue to be cut can be sucked via the cutting opening 7 against the knife 8. In this manner, further, fluid, blood and cut-off tissue can be suctioned. Fig. 1 further shows that between the compressed air source 10 and the electromagnetically operable valve 12, a reducing valve 27 is arranged, for instance for reducing a pressure source pressure of 6 bar to a pressure of 2.6-3 bars to be applied to the valve 12.

It will be clear that the invention is not limited to the embodiment shown here. In particular, the pneumatic operating cylinder 9 can be designed in different ways and further the frequency control and the pulse width modulation can be realized in many different ways. Such variations will be clear to the skilled person and are understood to fall within the scope of the invention as set forth in the following claims.

CLAIMS

1. A surgical cutter, in particular for cutting eye tissue, comprising a cutting member and a pneumatic drive for driving a cutting movement of the cutting member in a cutting frequency, further comprising a compressed air supply for supplying compressed air in compressed air pulses to the drive, and a frequency control for controlling the pulse frequency in which the compressed air pulses are supplied to the drive, <u>characterized in that</u>, further, control means are provided for reducing, with increasing pulse frequency, the amount of energy supplied per compressed air pulse.

2. A surgical cutter according to claim 1, wherein the control means comprise modulation means for modulating the pulse width of the compressed air pulses.

3. A surgical cutter according to claim 2, wherein the control means comprise a microprocessor.

4. A surgical cutter according to claim 3, wherein the frequency control and the control means are integrated in the microprocessor.

5. A surgical cutter according to any one of the preceding claims, wherein, further, means are provided for measuring the compressed air pressure in the cylinder and/or supply line.

6. A surgical cutter according to any one of the preceding claims, wherein the compressed air supply is provided with at least two compressed air supply valves which are arranged to be operated in opposite phase.

7. A surgical cutter according to any one of the preceding claims, wherein the pneumatic drive comprises a pneumatic operating cylinder with a plunger which is under spring action.

8. Control means for modulating, depending on a pulse frequency, the width of a compressed air pulse to be delivered by a compressed air valve to a

pneumatic drive, evidently intended or suitable for use with a surgical cutter according to any one of the preceding claims.

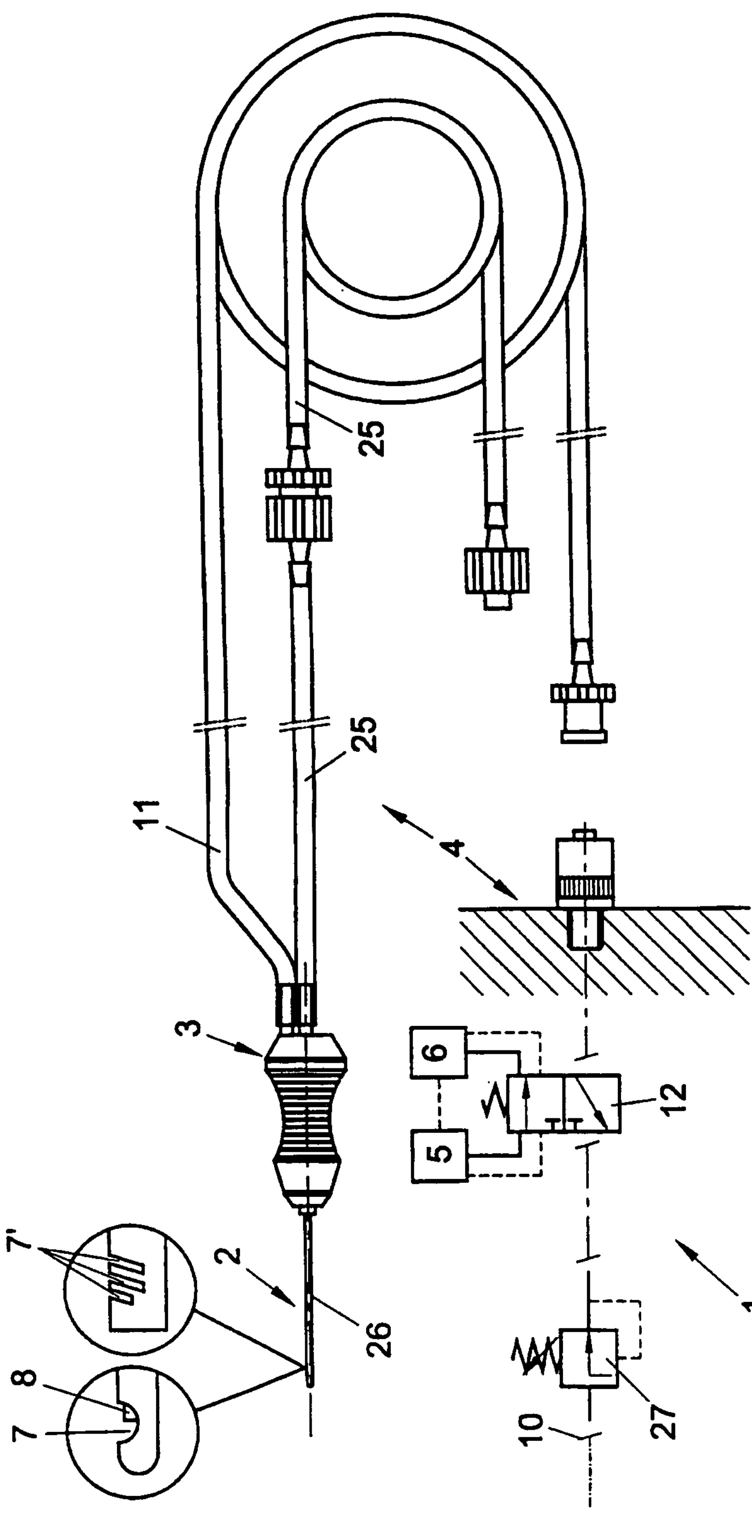

FIG. 1

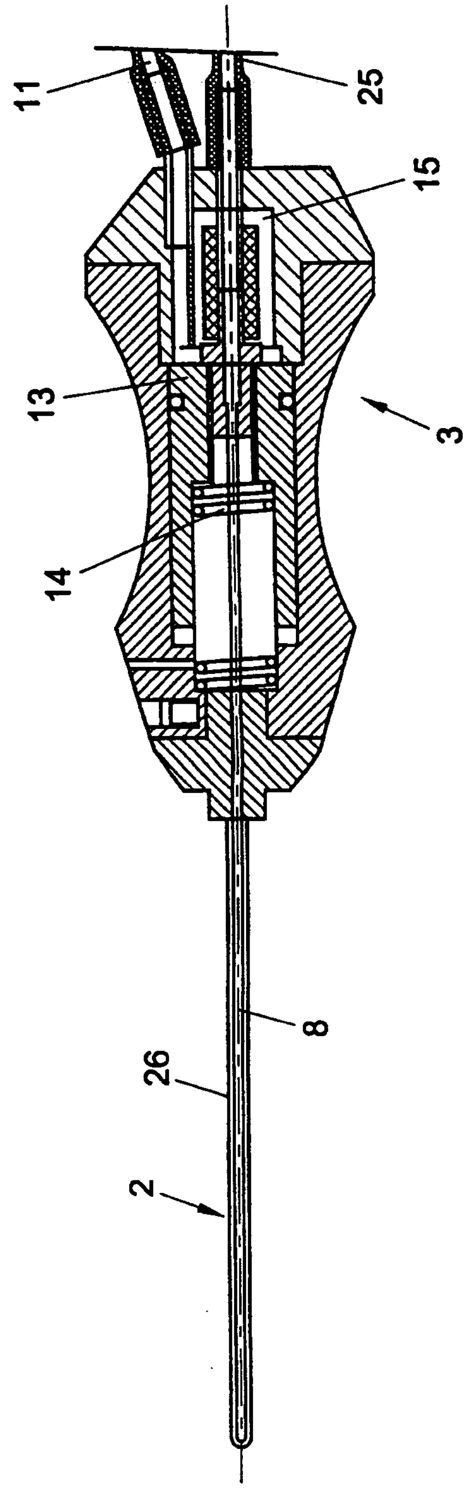

FIG. 2

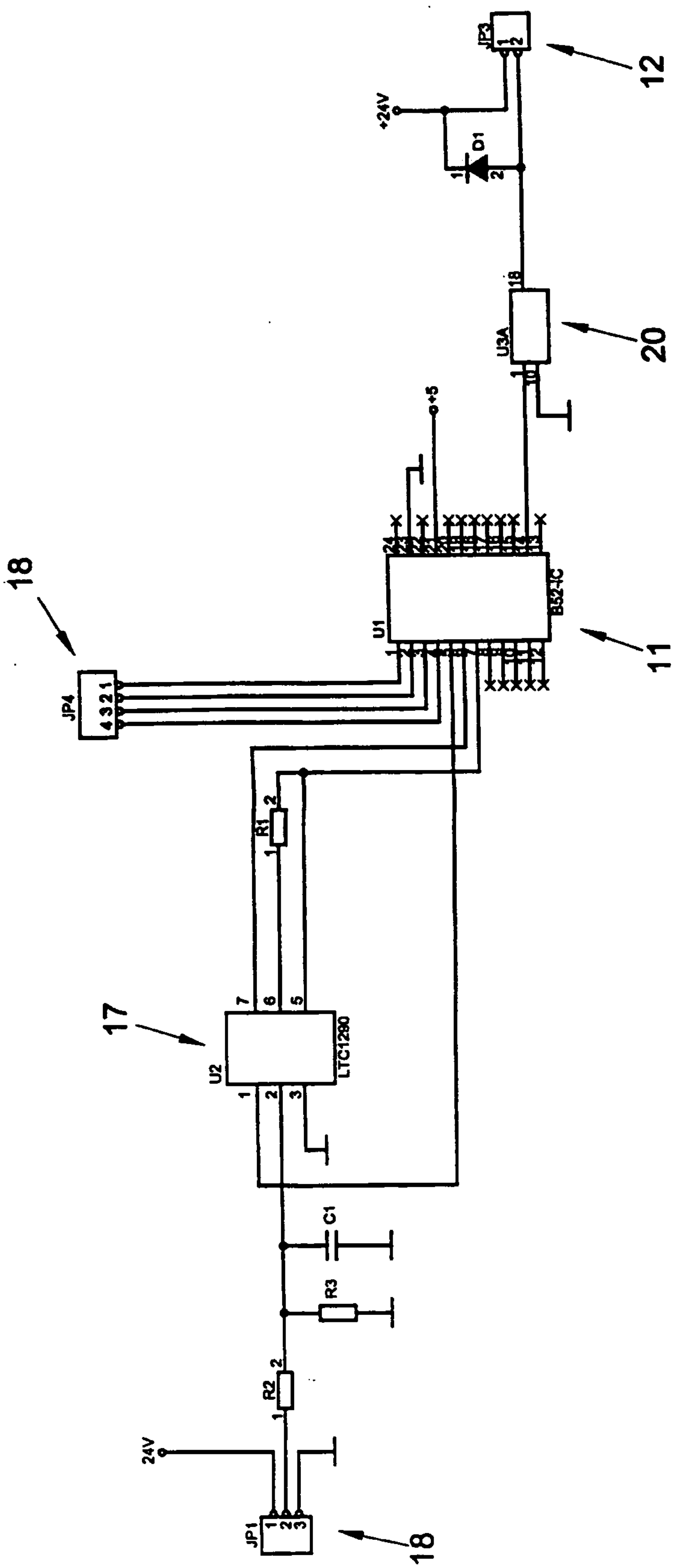
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FIG. 3

INTERNATIONAL SEARCH REPORT

Inte 'onal Application No
PCT/NL 00/00766

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61F9/007

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 630 827 A (VIJFVINKEL) 20 May 1997 (1997-05-20) column 2, line 10 - line 12; figure 7 column 4, line 42 - line 49	1,5,7
X	US 4 838 259 A (GLUCK) 13 June 1989 (1989-06-13)	8
A	figures 1,3,4	2,5
X	US 4 940 468 A (PETILLO) 10 July 1990 (1990-07-10) figure 12	1,5,7
A	US 4 753 234 A (MARTINEZ) 28 June 1988 (1988-06-28) column 3, paragraph 2; figure 1	1,5,7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2001	09/02/2001
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Barton, S

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INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/NL 00/00766

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 46164 A (SCIERAN) 11 December 1997 (1997-12-11) page 17 -page 18; figure 13 -----	6

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ional Application No
PCT/NL 00/00766

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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